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# (54) HYBRID POWERTRAIN VEHICLE

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VEHICULE A GROUPE MOTOPROPULSEUR HYBRIDE

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(56) References cited:

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| US-A- 4 372 414 | US-A- 4 993 780 |
| US-A- 5 024 489 | US-A- 5 088 041 |





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## Description

### BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention is a unique automotive hybrid powertrain design that allows highly efficient use of energy generated by an integrated internal or external combustion engine. The field of application is in propulsion systems for motor vehicles.

2. The Prior Art

[0002] The growing utilization of automobiles greatly adds to the atmospheric presence of various pollutants including greenhouse gases such as carbon dioxide. For this reason, there has been a quest for approaches to improve the efficiency of fuel utilization for automotive powertrains. Current powertrains typically average only about 10 to 15% thermal efficiency.

[0003] Conventional automotive powertrains result in significant energy loss, make it difficult to effectively control emissions, and offer limited potential to bring about major improvements in automotive fuel economy. Conventional powertrains consist of an internal combustion engine and a simple mechanical transmission having a discrete number of gear ratios. Due to the inefficiencies described below, about 85% to 90% of the fuel energy consumed by such a system is wasted as heat. Only 10%-15% of the energy is available to propel the vehicle, and much of this is dissipated as heat in braking.

[0004] Much of the energy loss is due to a poor match between engine power capacity and average power demand. The load placed on the engine at any given instant is directly determined by the total road load at that instant, which varies between extremely high and extremely low load. To meet acceleration requirements, the engine must be many times more powerful than the average power required to propel the vehicle. The efficiency of an internal combustion engine varies significantly with load, being best at higher loads near peak load and worst at low load. Since engine operation experienced in normal driving is nearly always at the low end of the spectrum, the engine must operate at poor efficiency much of the time, even though some conventional engines have peak efficiencies in the 35% to 40% range.

[0005] Another major source of energy loss is in braking. In contrast to acceleration which requires delivery of energy to the wheels, braking requires removal of energy from the wheels. Since an internal combustion engine can only produce and not reclaim energy, a conventional powertrain is a one-way energy path. Braking is achieved by a friction braking system, which renders useless the temporarily unneeded kinetic energy of the vehicle by converting it to heat.

[0006] The broad variation in speed and load experienced by the engine in a conventional powertrain also makes it difficult to effectively control emissions because it requires the engine to operate at many different conditions of combustion. Operating the engine at more constant speed and load would allow much better optimization of any emission control devices, and the overall more efficient settings of the engine would allow less fuel to be combusted per mile traveled.

[0007] Conventional powertrains offer limited potential to bring about improvements in automotive fuel economy except when combined with improvements in aerodynamic drag, weight, and rolling resistance. Such refinements can only offer incremental improvements in efficiency, and can apply equally well with improved powertrains.

[0008] Hybrid vehicle systems have been investigated as a means to mitigate the foregoing inefficiencies. A hybrid vehicle system provides a "buffer" between the power required to propel the vehicle and the power produced by the internal combustion engine in order to moderate the variation of power demand experienced by the engine. The buffer also allows regenerative braking because it can receive and store energy from sources other than the engine. The effectiveness of a hybrid vehicle system depends on its ability to operate the engine at peak efficiencies and on the capacity and efficiency of the buffer medium. Typical buffer media include electric batteries, mechanical flywheels and hydraulic accumulators.

[0009] To use a hydraulic accumulator as the buffer, a hydraulic pump/motor is integrated into the system. The pump/motor interchangeably acts as a pump or motor. As a pump, the pump/motor uses engine or "braking" power to pump hydraulic fluid to an accumulator where it is pressurized against a volume of gas (e.g., nitrogen). As a motor, the pressurized fluid is released through the pump/motor, producing power.

[0010] There are two general classes of hydraulic hybrid vehicle systems. A "series" system routes all of the energy produced by the engine through a fluid power path and so it is the fluid power side that experiences the variable road load. This improves efficiency because the efficiency of the fluid power path is not as sensitive to the power demand variations, and because the engine is thus decoupled from road load, allowing it to operate at peak efficiency or be turned off. Series systems are relatively simple in concept and control, but have less efficiency potential than other systems because all energy must be converted to fluid power and back to mechanical power to propel the vehicle. They also depend on frequent on/off operation of the engine for optimum efficiency. "Parallel" systems split power flow between a direct, almost conventional mechanical drive line and a fluid power path. Thus, some of the energy is spared the conversion to fluid power and back again. The most common context for such systems are in a "launch assist" mode where the hydraulic system serves

mainly to store braking energy and to redeliver it to assist in the next vehicle acceleration. The parallel system, because it requires both a conventional and a hydraulic power path to the wheels, tends to be more complex than the series system and more difficult to control for smoothness. Depending on the specific design, both series and parallel systems allow some reduction of engine size but both still tend to require a relatively large engine.

**[0011]** For example, U.S. Patent 4,223,532 (September 23, 1980), issued to Shiber, discloses a hydraulic hybrid transmission system which utilizes two pump/motors and is based on a theory that encourages intermittent engine operation.

## SUMMMARY OF THE INVENTION

**[0012]** Accordingly, it is an object of the present invention to provide a hybrid powertrain system which allows for significant reduction of size of the vehicle's internal combustion engine.

**[0013]** It is a further object of the present invention to provide a powertrain system which allows the vehicle's internal combustion engine to be constantly operated at near peak efficiency.

**[0014]** It is yet a further object of the present invention to provide a hybrid propulsion system wherein presently unneeded power generated by the internal combustion engine can be stored in a "buffer" for use to produce driving force (1) at such times when the internal combustion engine alone is insufficient to provide the output torque demanded of the vehicle and (2) at times of very low power demand when engine operation would be inefficient, e.g. in a traffic jam.

**[0015]** Still another object of the present invention is to provide a powertrain design that allows a more highly efficient use of energy generated by the internal combustion engine than heretofore possible.

**[0016]** Still another object of the present invention is to provide a hybrid powertrain propulsion system which allows for extreme variations in road load while maintaining high efficiency.

**[0017]** The present invention provides a unique "parallel" hybrid propulsion system and method of operation which meet the above-stated objectives. Specifically, the hybrid powertrain vehicle of the present invention includes a vehicle frame supported above a road surface by drive wheels rotatably mounted thereon. A primary engine, e.g. an internal or external combustion engine, mounted on the vehicle frame provides output engine power and an output shaft in a conventional manner. A power storage device is also mounted on the vehicle frame to serve as a "buffer", i.e. for storing and releasing braking and "excess" engine power. A first drive train serves to transmit the engine power to the drive wheels and includes a continuously variable transmission (CVT) having the usual movable pulley of variable effective diameter (or other multiple gear ratio transmission).

**[0018]** In a preferred embodiment, a reversible fluidic displacement means or "reversible pump/motor," is interposed between a fluid pressure accumulator and the first drivetrain to output motor power to the first drivetrain, driven by the accumulator fluid pressure in a first mode and to operate as a pump, driven by the first drivetrain, to store fluid pressure in the accumulator in a second mode. In other embodiments the reversible means could be, for example, the combination of a storage battery, generator/alternator and an electric motor.

**[0019]** A second drivetrain serves to connect the power storage device to the first drivetrain thereby defining a "parallel" propulsion system.

**[0020]** Control of the propulsion system is provided for, in part, by three sensors, i.e. a vehicle speed sensor, a power storage sensor, e.g. a pressure sensor for sensing fluid pressure within the accumulator and a torque (or power) demand sensor for sensing torque (or power) demanded of the vehicle by the driver, e.g. a sensor for "throttle" pedal position or "accelerator" pedal depression. A microprocessor includes comparing means for comparing the sensed value of stored power with a predetermined minimum value for stored power and for generating a demand signal upon a determination that the sensed value for stored power is at or below the predetermined minimum value. The microprocessor also includes a torque output determining means for determining an additional torque in accordance with the demand signal and for determining an engine output torque as the sum of the sensed torque demand and the additional torque. The microprocessor also includes an engine speed determining processor for determining an engine speed of optimum efficiency in accordance with the determined engine output torque and the sensed vehicle speed and for outputting a transmission signal, indicative of the determined engine speed. An engine speed control means controls the rotary speed of the output shaft of the engine by changing the gear ratio of the transmission. In the preferred embodiment this involves changing the effective diameter of the movable pulley of the CVT, responsive to the transmission signal output by the engine speed determining processor. An engine load controller controls engine power by controlling the fuel feed to the primary combustion engine responsive to the transmission signal. A mode controller serves to switch the power storage device between power storing and power release modes. In the preferred embodiment the mode controller serves both to convert operation of the fluid displacement means between the first and second modes of operation, responsive to the demand signal, and to vary the displacement of the fluid displacement means responsive to the sensed fluid pressure.

**[0021]** Optionally, a secondary, e.g. internal combustion, engine is mounted on the vehicle frame to provide for additional engine capacity which might be needed, for example, to climb a particularly steep grade. When

a secondary engine is mounted on the vehicle, a secondary engine clutch is interposed between the output of the secondary engine and the first drive train for matching the output speed of the secondary engine with the output of the primary engine.

[0022] The propulsion system of the present invention optionally further includes a free wheel clutch interposed between the transmission (CVT) and the drive wheels for disengaging the drive wheels from the first drive train responsive to a signal indicating zero power demand.

[0023] In the present invention the propulsion system is controlled by sensing vehicle speed, sensing fluid pressure within a fluid pressure accumulator and sensing power demanded of the vehicle by the driver. A reversible fluidic displacement device (pump/motor) is switched between a pump mode and a motor mode responsive to torque demand and available fluid pressure stored in the accumulator. The sensed fluid pressure is compared with a predetermined minimum fluid pressure and, if determined to be below the predetermined fluid pressure, a demand signal is generated. The additional torque necessary for adequately raising fluid pressure is determined in accordance with the demand signal and an engine output torque is determined as the sum of the sensed torque demand and the determined additional torque. An engine speed controller controls the rotary speed of the output shaft by changing the effective diameter of a movable pulley of the CVT responsive to a transmission signal. An engine speed processor, in turn determines an engine speed of optimum efficiency in accordance with the determined engine output torque and the sensed vehicle speed and outputs a transmission signal indicative of the determined engine speeds. The output power of the internal combustion engine is controlled by controlling fuel feed thereto responsive to the transmission signal.

[0024] In contrast to the prior art, the present system requires only one pump/motor in the primary drivetrain and uses the hydraulic subsystem in such a way as to utilize a very small prime engine and keeps the engine on as much as possible.

[0025] The invention is a unique type of "parallel" system, but can operate in a series configuration as well. The system of the present invention includes a very small engine sized near the average power requirement rather than the peak power requirement. The hydraulic subsystem acts as a power-trimming device to "trim" the power demand experienced by the engine. That is, the hydraulic subsystem's main purpose is to keep the engine operating as close as possible to its peak efficiency, by placing additional load on the engine at times of low propulsion power demand and delivering additional power at times of high or peak propulsion power demand. In the present invention a single hydraulic pump/motor and an accumulator achieve both functions. To place additional load on the engine, the engine is run at a power level corresponding to peak efficiency and the excess power is routed through the hydraulic pump/motor (operating as a pump) into the accumulator where it is stored with very little energy loss. To deliver additional power, the stored energy is discharged to the powertrain through the hydraulic pump/motor (operating as a motor).

[0026] In its simplest configuration, a clutching arrangement between the transmission and wheels allows free-wheeling when no power is needed from the powertrain. However, for simplicity, no clutching is provided between the engine, hydraulic pump/motor, and transmission. Therefore, the engine may occasionally be motoring while the pump/motor is charging the accumulator during regenerative braking or when delivering small amounts of power by itself. This creates a drag on the power train that reduces efficiency somewhat. The friction losses associated with this arrangement are minimal due to the small displacement of the internal combustion engine and the small amount of time in this mode of operation.

[0027] The present invention includes at least two configurations for hydraulic regenerative braking. In the first embodiment, friction brakes are activated first, after which hydraulic braking is phased in. This method reduces the sophistication of the controls that would be needed to effect a smooth routing of power from the wheels, and allows safety in case of a hydraulic system failure. In the second embodiment, hydraulic braking occurs first with friction brakes added as a backup system. This second embodiment is somewhat more complex to control, but is the preferred embodiment because it maximizes the recovery of braking energy.

[0028] When accelerating from a stop, the engine provides power to the wheels through the non-hydraulic portion of the driveline. If more power is needed than the engine can provide, additional power is supplied by the pump/motor acting as a motor. The accumulator is of sufficient size to allow this additional power to be provided two or more times in succession. Accumulator capacity for at least one acceleration is needed for regenerative braking and capacity for another is needed as backup in case a stop does not allow regenerative braking.

[0029] When cruising speed is reached and power demand drops off to a low level, the engine output matches the road load because the engine is small enough that its peak efficiency corresponds to loads characteristic of average road load. If more power is required of the engine in order to maintain peak operating efficiency, an additional load is provided by charging the accumulator through the pump/motor acting as a pump. If the accumulator can accept no more charge, the pump/motor is set to zero displacement and the engine merely runs at a reduced power output. Since the engine is sized close to the average power load during cruising, there is little or no sacrifice in efficiency at this setting. The engine can also be turned off and the accumulator can drive the pump/motor acting as a motor, if the load is very low as would occur in low speed, stop and go traffic.

[0030] When braking occurs, and if there is sufficient unused storage capacity reserved in the accumulator, regenerative braking occurs where the pump/motor acts as a pump to charge the accumulator. If there is no capacity left in the accumulator, friction brakes are used. The system is managed so that there will normally be sufficient capacity available for regenerative braking.

[0031] If sudden acceleration is required during a cruising period, this may be provided by boosting the output of the engine along the best efficiency line. After the maximum efficient engine power output point is reached, the hydraulic subsystem is activated to retrieve additional power from the accumulator via the pump/ motor.

[0032] When the car creeps along at a very low speed, as in a traffic jam, the engine is turned off and the pump/ motor and accumulator are used to drive the car. This is better than using the engine alone in such a mode because a pump/motor can operate at a good efficiency even at low speeds and low power demands.

[0033] Through proper choice of component sizes and control system optimization, the system can be designed to optimize various goals. For instance, one could minimize the chance of either: a) encountering a fully charged accumulator when regenerative braking energy becomes available, or b) depleting the accumulator by several rapid accelerations without chance to recharge the accumulator.

[0034] The use of a small engine supplemented by an accumulator of finite energy storage capacity presents a difficulty in ascending long grades. Just as with acceleration, ascending a grade requires an unusually large amount of power, but unlike an acceleration a long grade requires this power for an extended period of time. Since the theory of operation of the invention is to provide a large portion of acceleration power by means of a hydraulic accumulator, a long grade would deplete the accumulator in short order and the vehicle would be left with insufficient power.

[0035] As an alternative to an extremely large accumulator capacity, a second engine, which can be inexpensive and of only moderate durability due to its occasional use, may be clutched in to supplement the power of the primary engine and pump/motor for an unlimited time.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Fig. 1 is a schematic diagram of a first embodiment of a vehicle equipped with a hybrid powertrain propulsion system of the present invention.

[0037] Figs. 2a, 2b, 2c and 2d are graphs of engine load versus engine speed in various modes of operation of the system depicted in Fig. 1.

[0038] Fig. 3 is a schematic illustration of a vehicle equipped with a second embodiment of a hybrid powertrain propulsion system in accordance with the present invention.

[0039] Fig. 4 is a schematic illustration of a vehicle equipped with a third embodiment of a hybrid powertrain propulsion system in accordance with the present invention.

[0040] Fig. 5 is a schematic illustration of a vehicle equipped with a fourth embodiment of a hybrid powertrain propulsion system in accordance with the present invention.

[0041] Fig. 6 is a logic flow diagram for control of operation of a vehicle by a microprocessor in accordance with the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0042] Fig. 1 illustrates an embodiment of the present invention suitable for driving a three to four thousand pound vehicle. A very small internal combustion engine 1 (e.g. 20 hp) provides energy to the system. The energy is transmitted along the driveshaft 2, which constitutes a first drivetrain, and can be routed either to the transmission 3, in this embodiment a continuously-variable transmission (CVT), or to the pump/motor 7 (acting as a pump in the second mode) or both. The pump/motor 7 is a reversible hydraulic displacement device, e.g. a swash plate pump in which flow reversal is inherent to the pump or a bent axis pump wherein flow reversal is by valving external to the pump, capable of operating either in a first mode as a motor or in a second mode as a pump. The pump/motor 7 has a variable displacement. Energy routed to the pump/motor 7 (acting as a pump) is used to pump fluid to the accumulator 6, pressurizing the fluid B against a volume of gas A. Energy routed to the transmission flows along the lower driveshaft 9 past the freewheel clutch 4 to the wheels 5. The pump/motor 7 is switched between its first and second modes and its displacement is varied by a pump/motor controller 20, responsive to a signal FPs.

[0043] When the power demanded at the wheels 5 is larger than the power deliverable by the engine 1 alone, additional power is provided by the pump/motor 7 (acting as a motor in the first mode). In this mode the pressurized fluid in the accumulator 6 flows to the pump/motor 7 (acting as a motor), creating mechanical power that flows along the drive shaft 30 to driveshaft 2, to the transmission 3 and flows to the wheels as already described. The hydraulic accumulator 6, pump/motor 7 and shaft 30 constitute a second drivetrain, "parallel" to the first drivetrain.

[0044] Indicated at 26 is an engine control device, e. g. a fuel injection pump, which controls fuel feed to the engine 1, responsive to a signal Es which is a function of engine speed. Signal Es may be computed by processor 18 or may be a signal received directly from an rpm sensor 40.

[0045] The control hardware for operation of the vehicle includes a vehicle speed sensor, e.g. rpm sensor 12, which detects the rotational speed of the drive shaft

downstream of the freewheel clutch 4, a pressure sensor 16 for detecting the pressure within the fluid pressure accumulator 6 and generating a signal Ps representative of the detected pressure and a power demand sensor 14, e.g. a sensor for detecting position of the "accelerator pedal." A first processor 42 receives the signal Ps representative of the fluid pressure detected by sensor 16 and compares that detected fluid pressure with a predetermined minimum fluid pressure and generates a demand signal FPs upon determination that the sensed fluid pressure is below the predetermined minimum fluid pressure. That demand signal FPs is sent to the pump controller 20 for conversion of the pump/motor 7 to the second mode for operation as a pump, to store energy in the accumulator 6 in the form of fluid pressure.

**[0046]** A second processor 44 determines an additional power in accordance with the demand signal FPs and an engine output power as the sum of the power demand sensed by 14 and the determined additional power. A third processor 46 determines the engine speed of optimum efficiency in accordance with the determined total engine output power, and with the sensed vehicle speed outputs a transmission signal Ts, indicative of the determined optimum engine speed to the engine speed controller 24. Controller 24 regulates engine speed responsive to the signal Ts by changing the effective diameter of pulley 22 of the CVT 3. Processors 42, 44 and 46 may optionally be combined into a single microprocessor 18 including a memory 48. The signal Ts is determined by reference to a two dimensional map stored in memory 48 wherein values for optimum efficient power and engine speed are correlated. Knowing the desired engine speed and the vehicle speed from sensor 12, signal Ts is computed. This control system is likewise applicable to the other embodiments described hereinbelow.

**[0047]** An optional secondary engine 10 can provide yet additional reserve power. In this case an electronically controlled clutch 11 is engaged through which the power from engine 10 feeds into the system. The secondary engine 10 provides backup power for severe or repeated accelerations and for continuous operation to maintain speed up long and/or steep grades. The secondary engine 10 and clutch 11 can be installed as shown (to supply power to the drive shaft 2) or to supply power to drive shaft 9 directly. The engine 10 may be electronically started and clutch 11 engaged responsive to a signal SEs generated as a function, for example, of the sensed "accelerator pedal" position and detected accumulator fluid pressure. The clutch 11 serves to engage the secondary engine at the output speed of the primary engine. The primary engine 1 and the secondary engine 10, in combination, might be regarded as the functional equivalent of a variable displacement engine.

**[0048]** When zero power is demanded at the wheels, the vehicle is changed over to a coasting mode, responsive to a signal Cs from the microprocessor 18, by disengagement of the freewheeling clutch 4. In this manner the vehicle is isolated from rotational friction losses in the drivetrain so that all of the kinetic energy of the vehicle is available for overcoming rolling resistance and aerodynamic drag. The clutch 4 is normally engaged and is disengaged only when zero power demand is detected by sensor 14.

**[0049]** When the driver brakes, regenerative braking occurs. Kinetic energy is transferred from the wheels 5 past the clutch 4 through the transmission 3 along the drive shaft 2 into the pump/motor 7 (acting as a pump). The pump/motor 7 pressurizes fluid and thereby stores the energy in the accumulator 6 in the same manner as described above.

**[0050]** Through fluid pressure in accumulator 6, the pump/motor 7, operating in its first mode as a motor may be used to start engine 1, thereby eliminating need for a conventional starter motor.

**[0051]** The operation of the invention will be more clearly understood in reference to FIGS. 2A-2D. In the following discussion the term "optimum efficiency" refers to a range of speed and load, i.e. (power) at which the efficiency of the engine 1 is deemed reasonably near its optimum efficiency, between points A and B.

**[0052]** Fig. 2A is a grapn which represents instances (Mode 1) when the power demanded is greater than that deliverable at optimum efficiency by the engine 1 (point B) in the embodiment of Fig. 1. In this case, that portion of load which exceeds B is provided by the pump/motor 7 (acting as a motor), while the engine 1 provides the rest. In embodiments where the engine and pump/motor shafts are not clutched or geared, the engine 1, pump/motor 7, and transmission 3 input shaft would operate at the same speed. A clutching arrangement or a gear reduction could be incorporated therein without changing the basic function of this mode.

**[0053]** Fig. 2B illustrates the operation of the system of Fig. 1 in a mode 2, i.e. when power demanded of engine 1 is within the range of optimum efficiency (between power levels A and B). This power demanded of engine 1 is determined by microprocessor 18 considering power demanded by driver 14 and whether power should be supplied to or extracted from the accumulator 6. If there is no need to replenish the accumulator 6, all of the power is provided by the engine 1, and the pump/motor 7 is stroked to zero displacement (i.e., neutral position) by controller 20 where it neither pumps fluid into the accumulator 6 nor provides power to the system.

**[0054]** Fig. 2C illustrates the situation where the engine 1 can satisfy the driver power demand, and there is need (i.e., the accumulator energy level has reached a predetermined minimum level, but the engine 1 can operate at an optimum power level, point (b)) or desire (i.e., need to operate the engine at its optimum efficiency as indicated by driver power demand point (a)) to replenish the accumulator (mode 3). While road load demanded is represented by either of the points (a) or (b) shown in Fig. 2C, the power output of the engine is increased along the optimum efficiency line to a point at

which sufficient excess power is generated, illustrated here by the point (c). The excess power that does not go to road load is fed into the pump/motor 7 (acting as a pump) which stores it in the accumulator 6 for future Mode 1 or Mode 4 events.

[0055] FIG. 2D illustrates mode 4 wherein an unusually small road load is experienced. In this case, the engine cannot deliver such a small amount of power at acceptable efficiency and significant pressure exists in the accumulator 6. The fuel flow to the engine 1 is turned off, and the pump/motor 7 (acting as a motor) provides power by itself.

[0056] Regenerative braking can be thought of as an extension of Mode 4 (Fig. 2D), in which power demand is zero and the vehicle must decelerate at a rate greater than rolling resistance and aerodynamic drag would provide. The driver activates the brakes, which in turn activate the pump/motor 7 (acting as a pump) which pressurizes fluid as previously described using the vehicle's kinetic energy taken through the drive shaft 2, transmission 3 and lower drive shaft 9. This results in a deceleration similar to that caused by friction braking, but the energy is saved in the accumulator 6 rather than discarded.

[0057] An alternate embodiment adapted for operation which is expected to involve more extensive stop and go driving is shown in Fig. 3. In continual stop and go driving, a mode is invoked in which the pump/motor directly drives the vehicle without assistance from the engine. In this case a clutch 8 is provided between the engine 1 and pump/motor 7 so as to disconnect the engine 1 in this mode and prevent friction associated with operation of the engine 1.

[0058] Yet another embodiment is shown in Fig. 4, wherein a second pump/motor 13 is provided between the transmission and the wheels. This configuration would allow regenerative braking energy to proceed through the second pump/motor 13 directly to the accumulator 6 without incurring frictional losses in passing through the transmission 3. If the drag of the second pump/motor 13 when in neutral is sufficiently low, the second pump/motor 13 can stay on line directly geared to the wheel drive 9 during all modes of driving. An option to eliminate this "in neutral" drag would be to add a clutch between the second hydraulic pump/motor 13 and the wheel drive 9. Since the second pump/motor 13 can also provide power to the wheels in acceleration and cruising modes, it allows the size of the first pump/motor 7 to be reduced. The smaller size of pump/motor 7 allows the pump/motors to be selectively operated so as to better match the size of the chosen motor to the power being demanded by the wheels, improving average efficiency. This is especially important for urban driving where low and modest accelerations are frequent driving modes and a smaller pump/motor 7 can supplement the primary engine 1 more efficiently for small power increments than a larger pump/motor. The addition of the second pump/motor 13 to handle high acceleration rates and steep, extended grades would also allow a significantly smaller transmission, which is especially important for CVTs. For steep grades, engine 10 could be activated and the pump/motor 7 could operate as a pump driving the pump/motor 13 as a motor. Alternatively, a pump could be attached to engine 10, eliminating clutch 11, to supply sustained power through pump/motor 13 as a motor.

[0059] Another embodiment shown in Fig. 5 includes the second engine 10 clutched directly into the drive shaft 9 either upstream or downstream of the free wheel clutch 4, rather than behind the primary engine 1 as in the embodiments of Figures 1, 3, and 4. This arrangement allows the energy produced by the second engine 10 to pass directly to the wheels 5 without incurring losses in the upstream components of the drive line, and allows a smaller transmission 3 and, if downstream, a smaller free wheel clutch 4. In either location, the second engine 10 supplies power for various purposes, including but not necessarily limited to providing additional power for sustained hill-climbing, providing additional acceleration power during times of extremely hard acceleration, providing emergency launching power in the case of accumulator depletion, providing backup power for normal acceleration in order to allow a reduced accumulator or pump/motor size, and for selective operation so as to better match the size of the chosen engine to the road load demand.

[0060] One possible modification of the embodiment shown in Fig. 3 would be to delete the transmission 3 and launch the vehicle with the pump/motor 7 through appropriate use of the free wheel clutch 4.

[0061] A possible modification of the embodiment shown in Fig. 4 would be to delete the transmission 3 (and optionally clutch 12) and add a clutch between the pump/motor 13 and the wheel drive 9. The vehicle would be launched with either the pump/motor 7 (retaining clutch 8) or the pump/motor 13. At vehicle speeds above a specified minimum (e.g. 20 miles per hour), engine 1 would be engaged and provide direct shaft power, and operation would proceed as previously described. This configuration would eliminate any risk of accumulator pressure depletion.

[0062] The logic flow for control by microprocessor 18 will now be described with reference to Fig. 6 of the drawings. Fig. 6 is a flow chart showing the flow of control processing by microprocessor or computer unit 18. At step S1 a determination is made in accordance with a signal from brake sensor 50 as to whether or not brakes are engaged. If the brakes are engaged (Y), the engine 1 is shutoff or disconnected to allow for regenerative braking with pump/motor 7 operating as a pump to convert the energy of the braking into fluid pressure stored in accumulator 6. At step S2 a determination is made as to whether or not braking in addition to the regenerative braking is required. If required, friction brakes are engaged. In step S3 a determination is made, in accordance with the signal from sensor 14, as

to whether or not power is demanded by the driver. If no power is demanded, processing continues to step S4 where accumulator pressure, determined as a function of the signal from sensor 16, is compared with a predetermined minimum value for accumulator pressure and, if below that predetermined value, the engine is allowed to remain running with pump/motor 7 operating as a pump to convert the engine power into stored energy in the form of fluid pressure. If the pressure comparison of step S4 determines that the sensed fluid pressure is above the predetermined minimum, the engine is shut-off or disconnected and the control processing cycle is restarted. If a determination is made in step S3 that power is demanded by the driver, the control processing proceeds to step S5 wherein a determination is made as to whether or not the engine is operating at optimum efficiency for the demanded output power and vehicle speed. This determination is made by reference to a map or curve for optimum efficiency on a plot of engine output torque (i.e., load) versus vehicle speed (each point on the curve represents a unique power level) stored in memory 48. If it is determined in step S5 that the engine 1 is operating within a range of optimum efficiency, control processing proceeds to step S6 where a determination is made as to whether or not the sensed fluid pressure is at or above a predetermined very high value for fluid pressure. If the fluid pressure is found to be above the predetermined very high value in step S6, the power demanded by the driver is supplied by operation of pump/motor 7 as a motor operated by fluid pressure released from accumulator 6. If the accumulator or fluid pressure is not at the predetermined very high value the control processing proceeds to step S7 wherein the sensed fluid pressure is compared against the predetermined very low value for fluid pressure and, if below that predetermined low value, processing proceeds to step S8 where determination is made as to the availability of additional engine power and, if additional engine power is available, that additional engine power is used to store additional fluid pressure in the accumulator with operation of pump/motor 7 as a pump. If the sensed fluid pressure is not below the predetermined very low value in S7 or if no engine power is determined to be available in step S8, the control processing returns to start. If, in step S5, it is determined that the engine 1 is not operating within a range of optimum efficiency, control processing proceeds to step S9 where determination is made as to whether or not the engine is operating at a range below optimum efficiency. If the determination in step S9 is positive, processing proceeds to step S10 where the sensed fluid pressure is compared against a predetermined low value for fluid pressure and, if below that predetermined low value, engine power is increased and pump/motor 7 operates as a pump to increase fluid pressure within accumulator 6. If, in step S10, it is determined that accumulator pressure is not "low" the demand for power is satisfied by driving the powertrain with operation of pump/motor 7 as a motor driven by fluid pressure released by accumulator 6.

[0063] If, in step S9, it is determined that the engine is not operating below the range for optimum efficiency, i.e. is operating above the range for optimum efficiency, processing proceeds to step S11 wherein the sensed fluid pressure is compared against a predetermined "very low" value for fluid pressure. If found to be below that "very low" value for fluid pressure in step S11, the secondary engine 10 is started and clutch 11 (in the embodiment of Fig. 1) is engaged so that both engines operate in series to drive the vehicle. If the determination in step S11 is positive the processing proceeds to step S12 where a determination is made as to a need for more power. If a need for additional power is determined, the pump/motor 7 is operated as a motor to provide that additional power. If, in step S11, a determination is made that the sensed fluid pressure is above the predetermined "very low" value for fluid pressure, the secondary engine is not started and, instead, the vehicle is driven by the primary engine 1 and pump/motor 7 operating as a motor.

[0064] The notes for Fig. 6 read as follows:

[1] Set Continuously Variable Transmission (CVT) ratio and hydraulic pump displacement to achieve desired degree of braking, up to drive wheel slippage.

[2] Set CVT ratio to achieve optimum engine speed/power.

[3] Set CVT ratio and hydraulic motor displacement to achieve optimum efficiency power.

[4] Set CVT ratio to achieve engine speed for maximum power.

[0065] The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being further indicated by the claims rather than limited by the foregoing description, and all changes which come within the meaning and range of the equivalents of the claims are therefore intended to be embraced therein.

## Claims

1. A hybrid powertrain vehicle comprising:

    a vehicle frame;
    drive wheels (5) rotatably mounted on said vehicle frame;
    a primary engine, mounted on said vehicle frame, for providing engine power by rotation of an output shaft;
    power storage means (6), mounted on said vehicle frame, for storing and releasing power generated by said primary engine;

first drive train means (2, 3, 9, 4) for transmitting said engine power to said drive wheels, said first drive train means including a transmission (3) having adjustable speed input and output;
reversible means (7) for selectively, while driven by said rotation of said engine in a first mode, transmitting said engine power to said power storage means or, operating as a motor in a second mode, transmitting stored power from said power storage means to said first drive train;
second drive train means (30), in parallel with at least a portion of said first drive train means, connecting said reversible means to said first drive train means, for, in said second mode, transmitting said stored power to said first drive train means and for, in said first mode, transmitting said rotation of said engine to said reversible means for transfer of a portion of said engine power to said power storage means simultaneously with transfer of the remainder of said engine power to said drive wheels;
vehicle speed sensor means (12) for sensing vehicle speed;
stored power sensor means (16) for sensing a quantity of power stored within said power storage means;
power demand sensing means (14) for sensing power demanded of the vehicle by a driver;
comparing means (42) for comparing said sensed quantity of stored power with a predetermined minimum amount of stored power and generating a demand signal upon determination that said sensed quantity is below said predetermined amount;
power output determining means (44) for determining an additional increment of power in accordance with said demand signal and for determining an engine output power as a sum of the sensed power demand and the additional increment of power;
engine speed control means (24) for controlling speed of said rotation of said output shaft by changing the input speed of said transmission responsive to a transmission signal;
engine speed determining means (46) for determining an engine speed of optimum efficiency in accordance with said determined engine output power and said sensed vehicle speed and for outputting the transmission signal, indicative of the determined engine speed, to said engine speed control means;
engine load control means (26) for controlling said engine power by controlling fuel feed to said primary engine responsive to said transmission signal; and
mode control means (20) for converting operation of said reversible means between said first and second modes responsive to the demand signal.

2. A hybrid powertrain vehicle according to claim 1 further comprising:

    a secondary engine (10);
    a secondary engine clutch (11) for connecting an output of said secondary engine to said first drive train means responsive to the sensed power demand.

3. A hybrid powertrain vehicle according to claim 2, wherein said comparing means compares the sensed power demand with a maximum power predetermined for said primary engine and generates a command signal for starting said secondary engine and for engaging said secondary engine clutch when said sensed power demand exceeds said predetermined maximum power.

4. A hybrid powertrain vehicle according to claim 3, wherein said command signal is generated only upon determination that said sensed quantity of stored power is below said predetermined amount.

5. A hybrid powertrain vehicle according to claim 1 further comprising a freewheel clutch (4) interposed between said transmission and said drive wheels for disengaging said drive wheels from said first drive train responsive to a signal indicative of zero sensed power demand.

6. A hybrid powertrain vehicle according to claim 1 further comprising a memory (48) containing a stored map correlating values for said optimum engine speed and engine output power; and wherein
said engine speed determining means applies said determined engine output power and said sensed vehicle speed to said map to determine the engine speed of optimum efficiency.

7. A method for controlling a vehicle equipped with the hybrid powertrain propulsion system including drive wheels (5), reversible drive means (7), a primary engine (1) for rotatable driving said drive wheels and said reversible drive means simultaneously in parallel, power storage means (6) for storing engine power generated by said primary engine, a transmission (3) having adjustable speed input and speed output and engine speed control means (24) for changing the input speed of said transmission, said method comprising:

    sensing vehicle speed;
    sensing a quantity of power stored within the power storage means;
    sensing power demanded of the vehicle by a

driver;

feeding power from the power storage means, through the reversible drive means, utilizing the reversible drive means as a motor for driving said drive wheels responsive to a signal indicating a demanded power above that output by the primary engine;

simultaneously (1) transmitting a portion of the output power of the primary engine into said power storage means, using said reversible drive means, responsive to a sensed quantity of stored power lower than a predetermined value and (2) transmitting the remainder of the output power of the primary engine to the drive wheels;

comparing the sensed quantity of stored power with a predetermined minimum value and generating a demand signal upon determining that the sensed quantity of stored power is below the predetermined low value;

determining an additional output power in accordance with the demand signal and determining an engine output power as the sum of the sensed power demand and the additional output power;

controlling the rotary speed of the primary engine by changing the input speed of the transmission responsive to a transmission signal; and

determining an engine speed of optimum efficiency in accordance with the determined engine output power and the sensed vehicle speed and outputting the transmission signal in accordance with the determined engine speed.

8. The method of claim 7 wherein said propulsion system includes a memory (48) containing a stored first map correlating values for optimum engine speed and determined engine output power, and a second map correlating values for vehicle speed and said transmission signals, each of said transmission speeds representing a transmission speed (gear) ratio to achieve optimum engine speed; and wherein

said determining of optimum engine speed is by applying the determined engine output power and a sensed vehicle speed to said maps to select an engine speed of optimum efficiency for said determined engine output power and said sensed vehicle speed and for setting said transmission signal.

9. A hybrid powertrain vehicle comprising:

a vehicle frame;

drive wheels (5) rotatably mounted on said vehicle frame;

a primary engine (1), mounted on said vehicle frame, for providing engine power as rotation of an output shaft;

a fluid pressure accumulator (6), mounted on said vehicle frame, for storing and releasing fluid pressure;

first drive train means (2, 3, 9, 4) for transmitting said engine power to said drive wheels, said first drive train means including a continuously variable transmission (3) having at least one pulley of variable effective diameter;

reversible fluidic displacement means (7) for, in a first mode, operating as a motor fluidically driven by fluid pressure released by said accumulator, to output motor power to said first drive train and for, in a second mode, operating as a pump driven by said rotation of said engine, through said first drive train, to store said fluid pressure;

second drive train means (30), connecting said fluidic displacement means to said first drive train means, for, in said first mode, transmitting said motor power to said first drive train means and for, in said second mode, transmitting engine power to said fluidic displacement means;

vehicle speed sensor means (12) for sensing vehicle speed;

pressure sensor means (16) for sensing the fluid pressure within said accumulator;

power demand sensing means (14) for sensing power demanded of the vehicle by a driver;

comparing means (42) for comparing said sensed fluid pressure with a predetermined minimum fluid pressure and generating a demand signal upon determination that said sensed fluid pressure is below said predetermined fluid pressure;

power output determining means (44) for determining an additional increment of power in accordance with said demand signal and for determining an engine output power as a sum of the sensed power demand and the additional increment of power;

engine speed control means (44) for controlling rotary speed of said output shaft by changing the effective diameter of said pulley responsive to a transmission signal;

engine speed determining means (46) for determining an engine speed of optimum efficiency in accordance with said determined engine output power and said sensed vehicle speed and for outputting the transmission signal, indicative of the determined engine speed, to said engine speed control means;

engine load control means (26) for controlling said engine power by controlling fuel feed to said primary engine responsive to said transmission signal; and

mode control means (20) for converting operation of said fluidic displacement means be-

tween said first and second modes responsive to the demand signal and for varying the displacement of said fluidic displacement means responsive to the sensed fluid pressure.

10. A hybrid powertrain vehicle according to claim 9 further comprising:

    a secondary engine (10);
    a secondary engine clutch (11) for connecting an output of said secondary engine to said first drive train means responsive to the sensed power demand.

11. A hybrid powertrain vehicle according to claim 10, wherein said comparing means compares the sensed power demand with a maximum power predetermined for said primary engine and generates a command signal for starting said secondary engine and for engaging said secondary engine clutch when said sensed power demand exceeds said predetermined maximum power.

12. A hybrid powertrain vehicle according to claim 11, wherein said command signal is generated only upon determination that said sensed fluid pressure is below said predetermined fluid pressure.

13. A hybrid powertrain vehicle according to claim 9 further comprising a freewheel clutch (4) interposed between said transmission and said drive wheels for disengaging said drive wheels from said first drive train responsive to a signal indicative of zero sensed power demand.

14. A hybrid powertrain vehicle according to claim 9 further comprising a memory (48) containing a stored map correlating values for said optimum engine speed and engine output power; and wherein

    said engine speed determining means applies said determined engine output power and said sensed vehicle speed to said map to determine the engine speed of optimum efficiency.

15. A method for controlling a vehicle equipped with the hybrid powertrain propulsion system including drive wheels (5), a primary engine (1) for powering the drive wheels, a reversible fluidic displacement means (7), an accumulator for accumulating fluid pressure (6), a continuously variable transmission (3) having a moveable pulley (22) of variable effective diameter and a controller for mechanically moving that pulley to change the effective diameter, said method comprising:

    sensing vehicle speed;
    sensing fluid pressure within the accumulator;
    sensing power demanded of the vehicle by a driver;
    feeding fluid pressure from the accumulator, through the reversible fluid displacement device, to utilize the reversible fluid displacement device as a motor for driving said drive wheels responsive to a signal indicating a demanded power above that output by the primary engine;
    pumping fluid pressure into the accumulator, using a portion of the output power of the primary engine to drive the reversible fluid displacement means as a pump, responsive to a sensed fluid pressure lower than a predetermined value;
    comparing the sensed fluid pressure with a predetermined minimum fluid pressure and generating a demand signal upon determining that the sensed fluid pressure is below the predetermined low fluid pressure;
    determining an additional output power in accordance with the demand signal and determining an engine output power as the sum of the sensed power demand and the additional output power;
    controlling the rotary speed of the primary engine by changing the effective diameter of the moveable pulley responsive to a transmission signal; and
    determining an engine speed of optimum efficiency in accordance with the determined engine output power and the sensed vehicle speed and outputting the transmission signal in accordance with the determined engine speed.

16. The method of claim 15 wherein said propulsion system includes a memory (48) containing a stored first map correlating values for optimum engine speed and determined engine output power, and a second map correlating values for vehicle speed and said transmission signals, each of said transmission speeds representing a transmission speed (gear) ratio to achieve optimum engine speed; and wherein

    said determining of optimum engine speed is by applying the determined engine output power and a sensed vehicle speed to said maps to select an engine speed of optimum efficiency for said determined engine output power and said sensed vehicle speed and for setting said transmission signal.

## Patentansprüche

1. Ein Fahrzeug mit Hybridantrieb, das folgendes umfaßt:

    einen Fahrzeugrahmen;
    Antriebsräder (5), die drehbar am Fahrzeugrahmen angebracht sind;

einen am Fahrzeugrahmen angebrachten Primärmotor (1), um durch die Rotation einer Antriebswelle eine Motorleistung bereitzustellen;
ein Leistungsspeichermittel (6), das am Fahrzeugrahmen angebracht ist, um die vom Primärmotor erzeugte Leistung zu speichern und abzugeben;
ein erstes Triebstrangmittel (2, 3, 9, 4), um die Motorleistung auf die Antriebsräder zu übertragen, wobei das erste Triebstrangmittel ein Getriebe einschließt (3), das eine einstellbare Geschwindigkeitseingabe und -ausgabe aufweist;
ein umkehrbares Mittel (7), um, während es durch die Rotation des Motors in einem ersten Modus angetrieben wird, die Motorleistung an das Leistungsspeichermittel zu übertragen oder um in einem zweiten Modus als ein Motor zu arbeiten, indem die gespeicherte Leistung vom Leistungsspeichermittel an den ersten Triebstrang zu übertragen wird;
ein zweites Triebstrangmittel (30), das in parallel mit mindestens einem Teil des ersten Triebstrangmittels angeordnet ist, um das umkehrbare Mittel mit dem ersten Triebstrangmittel zu verbinden, um im zweiten Modus die gespeicherte Leistung an das erste Triebstrangmittel zu übertragen und um im ersten Modus die Rotation des Motors an das umkehrbare Mittel zu übertragen, damit ein Teil der Motorleistung an das Leistungsspeichermittel gleichzeitig mit der Übertragung der verbliebenen Motorleistung an die Antriebsräder übertragen wird;
ein Fahrzeuggeschwindigkeitsensormittel (12) zum Abtasten der Fahrzeuggeschwindigkeit;
ein Sensormittel (16) für die gespeicherte Leistung, um eine Menge der innerhalb des Leistungsspeichermittels gespeicherten Leistung abzutasten;
ein Leistungsanforderungs-Sensormittel (14), um eine Leistung abzutasten, die von einem Fahrer vom Fahrzeug verlangt wird;
ein Vergleichsmittel (42) zum Vergleichen der abgetasteten Menge der gespeicherten Leistung mit einer vorbestimmten minimalen Menge der gespeicherten Leistung und zum Erzeugen eines Anforderungssignal, wenn bestimmt wird, daß die abgetastete Menge unter der vorbestimmten Menge liegt;
ein Leistungsausgabe-Bestimmungsmittel (44), um in Übereinstimmung mit dem Anforderungssignal einen zusätzlichen Anstieg der Leistung zu bestimmen und um eine Motorausgabeleistung als eine Summe der abgetasteten Leistungsanforderung und des zusätzlichen Anstiegs er Leistung zu bestimmen;
ein Motorgeschwindigkeits-Steuermittel (24), um die Geschwindigkeit der Rotation der Antriebswelle zu steuern, indem die Eingabegeschwindigkeit des Getriebes als Reaktion auf ein Getriebesignal verändert wird;
ein Motorgeschwindigkeits-Bestimmungsmittel (46), um in Übereinstimmung mit der bestimmten Motorausgabeleistung und der abgetasteten Fahrzeuggeschwindigkeit eine Motorgeschwindigkeit mit dem optimalen Wirkungsgrad zu bestimmen und um das Getriebesignal, das die bestimmte Motorgeschwindigkeit anzeigt, an das Motorgeschwindigkeits-Steuermittel auszugeben;
ein Motorbelastungs-Steuermittel (26) zum Steuern der Motorleistung, indem die Kraftstoffzuführung an den Primärmotor als Reaktion auf das Getriebesignal gesteuert wird; und
ein Modussteuersignal (20), um den Betrieb des umkehrbaren Mittels zwischen dem ersten und dem zweiten Modus als Reaktion auf das Anforderungssignal umzuschalten.

2. Ein Fahrzeug mit Hybridantrieb nach Anspruch 1, das weiterhin folgendes umfaßt:

einen Sekundärmotor (10);
eine Sekundärmotorkupplung (11) zum Verbinden einer Ausgabe des Sekundärmotors mit dem ersten Triebstrangmittel als Reaktion auf die abgetastete Leistungsanforderung.

3. Ein Fahrzeug mit Hybridantrieb nach Anspruch 2, worin das Vergleichsmittel die abgetastete Leistungsanforderung mit einer für den Primärmotor vorbestimmten maximalen Leistung vergleicht und ein Befehlssignal erzeugt, um den Sekundärmotor zu starten und um die Sekundärmotorkupplung in Eingriff zu bringen, wenn die abgetastete Leistungsanforderung die vorbestimmte maximale Leistung übersteigt.

4. Ein Fahrzeug mit Hybridantrieb nach Anspruch 3, worin das Befehlssignal nur dann erzeugt wird, wenn bestimmt wird, daß die abgetastete Menge der gespeicherten Leistung unter der vorbestimmten Menge liegt.

5. Ein Fahrzeug mit Hybridantrieb nach Anspruch 1, das weiterhin eine Freilaufkupplung (4) umfaßt, die zwischen dem Getriebe und den Antriebsrädern angeordnet ist, um die Antriebsräder als Reaktion auf ein Signal, das eine abgetastete Null-Leistungsanforderung anzeigt, aus dem ersten Triebstrang auszukoppeln.

6. Ein Fahrzeug mit Hybridantrieb nach Anspruch 1, das weiterhin einen Speicher (48) umfaßt, der ein gespeichertes Kennfeld enthält, das die Werte für die optimale Motorgeschwindigkeit und die Motor-

ausgabeleistung korreliert; und wobei

das Motorgeschwindigkeits-Bestimmungsmittel die bestimmte Motorausgabeleistung und die abgetastete Fahrzeuggeschwindigkeit an das Kennfeld anlegt, um die Motorgeschwindigkeit des optimalen Wirkungsgrads zu bestimmen.

7. Ein Verfahren zum Steuern eines mit dem Hybridantriebssystem ausgestatteten Fahrzeugs, das Antriebsräder (5), ein umkehrbares Antriebsmittel (7), einen Primärmotor (1) zum gleichzeitigen, parallelen, drehbaren Antreiben der Antriebsräder und des umkehrbaren Antriebsmittels, ein Leistungsspeichermittel (6) zum Speichern der vom Primärmotor erzeugten Motorleistung, ein Getriebe (3), das eine einstellbare Geschwindigkeitseingabe und Geschwindigkeitsausgabe aufweist, und ein Motorgeschwindigkeits-Steuermittel (24) zum Ändern der Eingabegeschwindigkeit des Getriebes einschließt, wobei das Verfahren folgendes umfaßt:

das Abtasten der Fahrzeuggeschwindigkeit;
das Abtasten einer Menge der innerhalb des Leistungsspeichermittels gespeicherten Leistung;
das Abtasten der Leistung, die von einem Fahrer vom Fahrzeug verlangt wird
das Zuführen der Leistung aus dem Leistungsspeichermittel mittels des umkehrbaren Antriebsmittels, indem das umkehrbare Antriebsmittel als ein Motor zum Antreiben der Antriebsräder als Reaktion auf ein Signal verwendet wird, das eine angeforderte Leistung anzeigt, die über jene liegt, die durch den Primärmotor ausgegeben wird;
das gleichzeitige (1) Übertragen eines Teils der Ausgabeleistung des Primärmotors in das Leistungsspeichermittel mittels der Verwendung des umkehrbaren Antriebsmittels, und zwar als Reaktion auf eine abgetastete Menge der gespeicherten Leistung, die niedriger als ein vorbestimmter Wert ist, und (2) das Übertragen der verbliebenen Ausgabeleistung des Primärmotors an die Antriebsräder;
das Vergleichen der abgetasteten Menge der gespeicherten Leistung mit einem vorbestimmten minimalen Wert und das Erzeugen eines Anforderungssignals, wenn bestimmt wird, daß die abgetastete Menge der gespeicherten Leistung unter dem vorbestimmten niedrigen Wert liegt;
das Bestimmen einer zusätzlichen Ausgabeleistung in Übereinstimmung mit dem Anforderungssignal und das Bestimmen einer Motorausgabeleistung als die Summe der abgetasteten Leistungsanforderung und der zusätzlichen Ausgabeleistung;
das Steuern der Rotationsgeschwindigkeit des Primärmotors, indem die Eingabegeschwindigkeit des Getriebes als Reaktion auf ein Getriebesignal geändert wird; und
das Bestimmen einer Motorgeschwindigkeit mit optimalem Wirkungsgrad in Übereinstimmung mit der bestimmten Motorausgabeleistung und der abgetasteten Fahrzeuggeschwindigkeit und das Ausgeben des Getriebesignals in Übereinstimmung mit der bestimmten Motorgeschwindigkeit.

8. Das Verfahren nach Anspruch 7, worin das Antriebssystem einen Speicher (48) einschließt, der ein gespeichertes erstes Kennfeld enthält, das die Werte für die optimale Motorgeschwindigkeit und die bestimmte Motorausgabeleistung korreliert, und ein zweites Kennfeld enthält, das die Werte für die Fahrzeuggeschwindigkeit und die Getriebesignale korreliert, wobei jede der Übertragungsgeschwindigkeiten ein Übertragungsgeschwindigkeits-(Getriebe)-Verhältnis darstellt, um die optimale Motorgeschwindigkeit zu erreichen; und worin

die Bestimmung der optimalen Motorgeschwindigkeit mittels der Anlegung der bestimmten Motorausgabeleistung und einer abgetasteten Fahrzeuggeschwindigkeit an die Kennfelder erfolgt, um für die bestimmte Motorausgabeleistung und die abgetastete Fahrzeuggeschwindigkeit eine Motorgeschwindigkeit mit einem optimalen Wirkungsgrad zu wählen und um das Getriebesignal einzustellen.

9. Ein Fahrzeug mit Hybridantrieb, das folgendes umfaßt:

einen Fahrzeugrahmen;
Antriebsräder (5), die drehbar am Fahrzeugrahmen angebracht sind;
einen am Fahrzeugrahmen angebrachten Primärmotor (1), um durch die Rotation einer Antriebswelle eine Motorleistung bereitzustellen;
einen Fluiddruckakkumulator (6), der am Fahrzeugrahmen angebracht ist, um den Fluiddruck zu speichern und abzugeben;
ein erstes Triebstrangmittel (2, 3, 9, 4), um die Motorleistung auf die Antriebsräder zu übertragen, wobei das erste Triebstrangmittel ein kontinuierlich veränderliches Getriebe einschließt (3), das mindestens eine Riemenscheibe mit einem veränderlichen effektiven Durchmessers aufweist;
ein umkehrbares Fluidverdrängungsmittel (7), das in einem ersten Modus als ein Motor arbeitet, der fluidisch durch den vom Akkumulator abgegebenen Fluiddruck angetrieben wird, um die Motorleistung an den ersten Triebstrang auszugeben, und das in einem zweiten Modus als eine Pumpe arbeitet, die mittels des ersten

Triebstrangs durch die Rotation des Motors angetrieben wird, um den Fluiddruck zu speichern;
ein zweites Triebstrangmittel (30), das das Fluidverdrängungsmittel mit dem ersten Triebstrangmittel verbindet, um im ersten Modus die Motorleistung an das erste Triebstrangmittel zu übertragen und um im zweiten Modus die Motorleistung an das Fluidverdrängungsmittel zu übertragen;
ein Fahrzeuggeschwindigkeitsensormittel (12) zum Abtasten der Fahrzeuggeschwindigkeit;
ein Drucksensormittel (16), um den Fluiddruck innerhalb des Akkumulators abzutasten;
ein Leistungsanforderungs-Abtastmittel (14), um eine Leistung abzutasten, die von einem Fahrer vom Fahrzeug verlangt wird;
ein Vergleichsmittel (42) zum Vergleichen des abgetasteten Fluiddrucks mit einem vorbestimmten minimalen Fluiddruck und zum Erzeugen eines Anforderungssignal, wenn bestimmt wird, daß der abgetastete Fluiddruck unter dem vorbestimmten Fluiddruck liegt;
ein Leistungsausgabe-Bestimmungsmittel (44), um in Übereinstimmung mit dem Anforderungssignal einen zusätzlichen Anstieg der Leistung zu bestimmen und um eine Motorausgabeleistung als eine Summe der abgetasteten Leistungsanforderung und des zusätzlichen Anstiegs der Leistung zu bestimmen;
ein Motorgeschwindigkeits-Steuermittel (24) zum Steuern der Rotationsgeschwindigkeit der Antriebswelle, indem der effektive Durchmesser der Riemenscheibe als Reaktion auf ein Getriebesignal verändert wird;
ein Motorgeschwindigkeits-Bestimmungsmittel (46), um in Übereinstimmung mit der bestimmten Motorausgabeleistung und der abgetasteten Fahrzeuggeschwindigkeit eine Motorgeschwindigkeit mit dem optimalen Wirkungsgrad zu bestimmen und um das Getriebesignal, das die bestimmte Motorgeschwindigkeit anzeigt, an das Motorgeschwindigkeits-Steuermittel auszugeben;
ein Motorbelastungs-Steuermittel (26) zum Steuern der Motorleistung, indem die Kraftstoffzuführung an den Primärmotor als Reaktion auf das Getriebesignal gesteuert wird; und
ein Modussteuersignal (20), um den Betrieb des Fluidverdrängungsmittels zwischen dem ersten und dem zweiten Modus als Reaktion auf das Anforderungssignal umzuschalten und um die Verdrängung des Fluidverdrängungsmittels als Reaktion auf den abgetasteten Fluiddruck zu verändern.

10. Ein Fahrzeug mit Hybridantrieb nach Anspruch 9, das weiterhin folgendes

einen Sekundärmotor (10);
eine Sekundärmotorkupplung (11) zum Verbinden einer Ausgabe des Sekundärmotors mit dem ersten Triebstrangmittel als Reaktion auf die abgetastete Leistungsanforderung.

11. Ein Fahrzeug mit Hybridantrieb nach Anspruch 10, worin das Vergleichsmittel die abgetastete Leistungsanforderung mit einer für den Primärmotor vorbestimmten maximalen Leistung vergleicht und ein Befehlssignal erzeugt, um den Sekundärmotor zu starten und um die Sekundärmotorkupplung in Eingriff zu bringen, wenn die abgetastete Leistungsanforderung die vorbestimmte maximale Leistung übersteigt.

12. Ein Fahrzeug mit Hybridantrieb nach Anspruch 11, worin das Befehlssignal nur dann erzeugt wird, wenn bestimmt wird, daß der abgetastete Fluiddruck unter dem vorbestimmten Fluiddruck liegt.

13. Ein Fahrzeug mit Hybridantrieb nach Anspruch 9, das weiterhin eine Freilaufkupplung (4) umfaßt, die zwischen dem Getriebe und den Antriebsrädern angeordnet ist, um die Antriebsräder als Reaktion auf ein Signal, das eine abgetastete Null-Leistungsanforderung anzeigt, aus dem ersten Triebstrang auszukoppeln.

14. Ein Fahrzeug mit Hybridantrieb nach Anspruch 9, das weiterhin einen Speicher (48) umfaßt, der ein gespeichertes Kennfeld enthält, das die Werte für die optimale Motorgeschwindigkeit und die Motorausgabeleistung korreliert; und wobei
das Motorgeschwindigkeits-Bestimmungsmittel die bestimmte Motorausgabeleistung und die abgetastete Fahrzeuggeschwindigkeit an das Kennfeld anlegt, um die Motorgeschwindigkeit des optimalen Wirkungsgrads zu bestimmen.

15. Ein Verfahren zum Steuern eines mit dem Hybridantriebs-system ausgestatteten Fahrzeugs, das Antriebsräder (5), einen Primärmotor (1) zum Antreiben der Antriebsräder, ein umkehrbares Fluidverdrängungsmittel (7), einen Akkumulator zum Akkumulieren des Fluiddrucks (6) und ein kontinuierlich veränderliches Getriebe (3) einschließt, das eine bewegliche Riemenscheibe (22) mit einem veränderlichen effektiven Durchmessers und einen Regler aufweist, um diese Riemenscheibe mechanisch zu bewegen, damit der effektive Durchmesser geändert wird, wobei das Verfahren folgendes umfaßt:

das Abtasten der Fahrzeuggeschwindigkeit;
das Abtasten des Fluiddrucks innerhalb des Akkumulators;
das Abtasten der Leistung, die von einem Fah-

rer vom Fahrzeug verlangt wird;
das Zuführen des Fluiddrucks aus dem Akkumulator mittels des umkehrbaren Fluidverdrängungsmittels, um das umkehrbare Fluidverdrängungsmittel als Motor zu verwenden, damit die Antriebsräder als Reaktion auf ein Signal angetrieben werden, das eine angeforderte Leistung anzeigt, die über jene, die durch den Primärmotor ausgegeben wird, liegt;
das Pumpen des Fluiddrucks in den Akkumulator, indem ein Teil der Ausgabeleistung des Primärmotors verwendet wird, um das umkehrbare Fluidverdrängungsmittel als Reaktion auf einen abgetasteten Fluiddruck, der niedriger ist als ein vorbestimmter Wert, als eine Pumpe anzutreiben;
das Vergleichen des abgetasteten Fluiddrucks mit einem vorbestimmten minimalen Fluiddruck und das Erzeugen eines Anforderungssignals, wenn bestimmt wird, daß der abgetastete Fluiddruck unter dem vorbestimmten niedrigen Fluiddruck liegt;
das Bestimmen einer zusätzlichen Ausgabeleistung in Übereinstimmung mit dem Anforderungssignal und das Bestimmen einer Motorausgabeleistung als die Summe der abgetasteten Leistungsanforderung und der zusätzlichen Ausgabeleistung;
das Steuern der Rotationsgeschwindigkeit des Primärmotors, indem der effektive Durchmesser der beweglichen Riemenscheibe als Reaktion auf ein Getriebesignal geändert wird; und
das Bestimmen einer Motorgeschwindigkeit mit optimalem Wirkungsgrad in Übereinstimmung mit der bestimmten Motorausgabeleistung und der abgetasteten Fahrzeuggeschwindigkeit und das Ausgeben des Getriebesignals in Übereinstimmung mit der bestimmten Motorgeschwindigkeit.

16. Das Verfahren nach Anspruch 15, worin das Antriebs-system einen Speicher (48) einschließt, der ein gespeichertes erstes Kennfeld enthält, das die Werte für die optimale Motorgeschwindigkeit und die bestimmte Motorausgabeleistung korreliert, und ein zweites Kennfeld enthält, das die Werte für die Fahrzeuggeschwindigkeit und die Getriebesignale korreliert, wobei jede der Übertragungsgeschwindigkeiten ein Übertragungsgeschwindigkeits-(Getriebe)-Verhältnis darstellt, um die optimale Motorgeschwindigkeit zu erreichen; und worin

die Bestimmung der optimalen Motorgeschwindigkeit mittels der Anlegung der bestimmten Motorausgabeleistung und einer abgetasteten Fahrzeuggeschwindigkeit an die Kennfelder erfolgt, um für die bestimmte Motorausgabeleistung und die abgetastete Fahrzeuggeschwindigkeit eine Motorgeschwindigkeit mit einem optimalen Wirkungsgrads zu wählen und um das Getriebesignal einzustellen.

## Revendications

1. Véhicule à groupe motopropulseur hybride comprenant :

- un châssis de véhicule ;
- des roues motrices (5) montées de façon rotative sur ledit châssis de véhicule ;
- un moteur principal, monté dans ledit châssis du véhicule, pour délivrer une puissance motrice par rotation d'un arbre de sortie ;
- des moyens d'emmagasinage d'énergie (6), montés dans ledit châssis du véhicule, pour emmagasiner et libérer une puissance générée par ledit moteur principal ;
- des premiers moyens formant train de transmission (2, 3, 9, 4) pour transmettre ladite puissance du moteur auxdites roues motrices, lesdits premiers moyens formant train de transmission comprenant une transmission (3) ayant une entrée et une sortie à vitesse réglable ;
- des moyens réversibles (7) pour sélectivement, en étant entraînés par ladite rotation dudit moteur dans un premier mode, transmettre ladite puissance du moteur auxdits moyens d'emmagasinage d'énergie ou, en agissant comme un moteur dans un deuxième mode, transmettre la puissance emmagasinée desdits moyens d'emmagasinage d'énergie audit premier train de transmission ;
- des deuxièmes moyens formant train de transmission (30), en parallèle avec au moins une partie desdits premiers moyens formant train de transmission, reliant lesdits moyens réversibles auxdits premiers moyens formant train de transmission afin, dans ledit deuxième mode, de transmettre ladite puissance emmagasinée auxdits premiers moyens formant train de transmission et afin, dans ledit premier mode, de transmettre ladite rotation dudit moteur auxdits moyens réversibles pour un transfert d'une partie de ladite puissance du moteur auxdits moyens d'emmagasinage d'énergie simultanément à un transfert du reste de ladite puissance du moteur auxdites roues motrices ;
- des moyens de détection de la vitesse du véhicule (12) pour détecter la vitesse du véhicule ;
- des moyens de détection de la puissance emmagasinée (16) pour détecter la quantité d'énergie emmagasinée dans lesdits moyens d'emmagasinage d'énergie ;
- des moyens de détection de la demande de puissance (14) pour détecter la puissance de-

mandée au véhicule par un conducteur ;

- des moyens de comparaison (42) pour comparer ladite quantité détectée d'énergie emmagasinée à une quantité minimale prédéterminée d'énergie emmagasinée et générer un signal de demande s'il est déterminé que ladite quantité détectée est inférieure à ladite quantité prédéterminée ;
- des moyens de détermination de la puissance de sortie (44) pour déterminer un incrément supplémentaire de puissance suivant ledit signal de demande et pour déterminer une puissance de sortie du moteur, en tant que somme algébrique de la demande de puissance détectée et de l'incrément supplémentaire de puissance ;
- des moyens de commande de la vitesse du moteur (24) pour commander la vitesse de ladite rotation dudit arbre de sortie en changeant la vitesse d'entrée de ladite transmission, en réponse à un signal de transmission ;
- des moyens de détermination de la vitesse du moteur (46) pour déterminer une vitesse du moteur de rendement optimum suivant ladite puissance de sortie du moteur déterminée et ladite vitesse du véhicule détectée et pour délivrer en sortie le signal de transmission, indicatif de la vitesse du moteur déterminée, auxdits moyens de commande de la vitesse du moteur ;
- des moyens de commande de la charge du moteur (26) pour commander ladite puissance du moteur en commandant l'alimentation en carburant dudit moteur principal, en réponse audit signal de transmission ; et
- des moyens de commande de mode (20) pour modifier le fonctionnement desdits moyens réversibles entre lesdits premier et deuxième modes, en réponse au signal de demande.

2. Véhicule à groupe motopropulseur hybride selon la revendication 1, comportant en outre :

- un moteur secondaire (10) ;
- un embrayage de moteur secondaire (11) pour relier la sortie dudit moteur secondaire auxdits premiers moyens formant train de transmission, en réponse à la demande de puissance détectée.

3. Véhicule à groupe motopropulseur hybride selon la revendication 2, dans lequel lesdits moyens de comparaison comparent la demande de puissance détectée à une puissance maximale prédéterminée pour ledit moteur principal et génèrent un signal de commande pour mettre en route ledit moteur secondaire et pour mettre en prise ledit embrayage de moteur secondaire lorsque ladite demande de puissance détectée dépasse ladite puissance maximale prédéterminée.

4. Véhicule à groupe motopropulseur hybride selon la revendication 3, dans lequel ledit signal de commande est généré seulement s'il est déterminé que ladite quantité détectée d'énergie emmagasinée est inférieure à ladite quantité prédéterminée.

5. Véhicule à groupe motopropulseur hybride selon la revendication 1, comportant en outre un embrayage de roue libre (4) interposé entre ladite transmission et lesdites roues motrices afin de désengager lesdites roues motrices dudit premier train de transmission, en réponse à un signal indicatif d'une demande de puissance détectée nulle.

6. Véhicule à groupe motopropulseur hybride selon la revendication 1, comportant en outre une mémoire (48) contenant un tableau mémorisé effectuant la corrélation de valeurs pour ladite vitesse du moteur optimale et la puissance de sortie du moteur ; et dans lequel lesdits moyens de détermination de la vitesse du moteur appliquent ladite puissance de sortie du moteur déterminée et ladite vitesse du véhicule détectée audit tableau afin de déterminer la vitesse du moteur de rendement optimum.

7. Procédé de commande d'un véhicule équipé du système de propulsion hybride comprenant des roues motrices (5), des moyens à entraînement réversible (7), un moteur principal (1) pour entraîner en rotation lesdites roues motrices et lesdits moyens à entraînement réversible simultanément et en parallèle, des moyens d'emmagasinage d'énergie (6) pour emmagasiner la puissance du moteur générée par ledit moteur principal, une transmission (3) ayant une vitesse d'entrée et une vitesse de sortie ajustables et des moyens de commande de la vitesse du moteur (24) pour changer la vitesse d'entrée de ladite transmission, ledit procédé comportant les étapes consistant à :

- détecter la vitesse du véhicule ;
- détecter la quantité d'énergie emmagasinée dans les moyens d'emmagasinage d'énergie ;
- détecter la puissance demandée au véhicule par le conducteur ;
- alimenter en énergie provenant des moyens d'emmagasinage d'énergie les moyens à entraînement réversible, en utilisant ces moyens à entraînement réversible en moteur pour entraîner lesdites roues motrices, en réponse à un signal indiquant une puissance demandée supérieure à celle délivrée en sortie du moteur principal ;
- simultanément (1) transmettre une partie de la puissance de sortie du moteur principal auxdits

moyens d'emmagasinage d'énergie, en utilisant lesdits moyens à entraînement réversible, en réponse à une quantité détectée d'énergie emmagasinée inférieure à une valeur prédéterminée et (2) transmettre le reste de la puissance de sortie du moteur principal aux roues motrices ;

- comparer la quantité détectée d'énergie emmagasinée à une valeur minimale prédéterminée et générer un signal de demande s'il est déterminé que la quantité détectée d'énergie emmagasinée est inférieure à la valeur basse prédéterminée ;
- déterminer une puissance de sortie supplémentaire selon le signal de demande et déterminer une puissance de sortie du moteur, en tant que somme algébrique de la demande de puissance détectée et de la puissance de sortie supplémentaire ;
- commander la vitesse de rotation du moteur principal en changeant la vitesse d'entrée de la transmission en réponse à un signal de transmission ; et
- déterminer une vitesse du moteur de rendement optimum suivant la puissance de sortie du moteur déterminée et la vitesse du véhicule détectée et délivrer en sortie le signal de transmission suivant la vitesse du moteur déterminée.

8. Procédé selon la revendication 7, dans lequel ledit système de propulsion comprend une mémoire (48) contenant un premier tableau mémorisé effectuant une corrélation des valeurs de vitesse optimale du moteur et de puissance de sortie du moteur déterminée, ainsi qu'un deuxième tableau effectuant une corrélation des valeurs de vitesse du véhicule et desdits signaux de transmission, chacune desdites vitesses de transmission représentant un rapport de vitesse de transmission pour obtenir une vitesse du moteur optimale ; et dans lequel ladite détermination de la vitesse optimale du moteur s'effectue en appliquant la puissance de sortie du moteur déterminée et la vitesse du véhicule détectée auxdits tableaux afin de sélectionner une vitesse du moteur de rendement optimum pour ladite puissance de sortie du moteur déterminée et ladite vitesse du véhicule détectée et pour établir ledit signal de transmission.

9. Véhicule à groupe motopropulseur hybride comportant :

- un châssis de véhicule ;
- des roues motrices (5) montées de façon rotative sur ledit châssis de véhicule ;
- un moteur principal (1), monté dans ledit châssis du véhicule, pour délivrer une puissance motrice par rotation d'un arbre de sortie ;
- un accumulateur de pression de fluide (6), monté dans ledit châssis du véhicule, pour emmagasiner et libérer une pression de fluide ;
- des premiers moyens formant train de transmission (2, 3, 9, 4) pour transmettre ladite puissance du moteur auxdites roues motrices, lesdits premiers moyens formant train de transmission comprenant une transmission continuellement variable (3) ayant au moins une poulie de diamètre effectif variable ;
- des moyens à déplacement de fluide réversibles (7) pour, dans un premier mode, en agissant en moteur entraîné par une pression de fluide libérée dudit accumulateur, développer une puissance motrice sur ledit premier train de transmission et pour, dans un deuxième mode, en agissant en pompe entraînée par ladite rotation dudit moteur, par l'intermédiaire dudit premier train de transmission, emmagasiner ladite pression de fluide ;
- des deuxièmes moyens formant train de transmission (30), reliant lesdits moyens à déplacement de fluide auxdits premiers moyens formant train de transmission afin, dans ledit premier mode, de transmettre ladite puissance motrice auxdits premiers moyens formant train de transmission et afin, dans ledit deuxième mode, de transmettre la puissance du moteur auxdits moyens à déplacement de fluide ;
- des moyens de détection de la vitesse du véhicule (12) pour détecter la vitesse du véhicule ;
- des moyens de détection de pression (16) pour détecter la pression de fluide régnant dans ledit accumulateur ;
- des moyens de détection de la demande de puissance (14) pour détecter la puissance demandée au véhicule par le conducteur ;
- des moyens de comparaison (42) pour comparer ladite pression de fluide détectée à une pression de fluide minimale prédéterminée et générer un signal de demande s'il est déterminé que ladite pression de fluide détectée est inférieure à ladite pression de fluide prédéterminée ;
- des moyens de détermination de la puissance de sortie (44) pour déterminer un incrément supplémentaire de puissance suivant ledit signal de demande et pour déterminer une puissance de sortie du moteur, en tant que somme algébrique de la demande de puissance détectée et de l'incrément supplémentaire de puissance ;
- des moyens de commande de la vitesse du moteur (44) pour commander la vitesse de rotation dudit arbre de sortie en changeant le diamètre effectif de ladite poulie, en réponse à un signal de transmission ;

- des moyens de détermination de la vitesse du moteur (46) pour déterminer une vitesse du moteur de rendement optimum suivant ladite puissance de sortie du moteur déterminée et ladite vitesse du véhicule détectée et pour délivrer en sortie le signal de transmission, indicatif de la vitesse du moteur déterminée, auxdits moyens de commande de la vitesse du moteur ;
- des moyens de commande de la charge du moteur (26) pour commander ladite puissance du moteur en commandant l'alimentation en carburant dudit moteur principal, en réponse audit signal de transmission ; et
- des moyens de commande de mode (20) pour modifier le fonctionnement desdits moyens à déplacement de fluide entre lesdits premier et deuxième modes, en réponse au signal de demande, et pour faire varier le volume desdits moyens à déplacement de fluide en réponse à la pression de fluide détectée.

**10.** Véhicule à groupe motopropulseur hybride selon la revendication 9, comportant en outre :

- un moteur secondaire (10) ;
- un embrayage de moteur secondaire (11) pour relier la sortie dudit moteur secondaire auxdits premiers moyens formant train de transmission en réponse à la demande de puissance détectée.

**11.** Véhicule à groupe motopropulseur hybride selon la revendication 10, dans lequel lesdits moyens de comparaison comparent la demande de puissance détectée à une puissance maximale prédéterminée pour ledit moteur principal et génèrent un signal de commande pour mettre en route ledit moteur secondaire et pour mettre en prise ledit embrayage de moteur secondaire lorsque ladite demande de puissance détectée dépasse ladite puissance maximale prédéterminée.

**12.** Véhicule à groupe motopropulseur hybride selon la revendication 11, dans lequel ledit signal de commande est généré seulement lorsqu'il est déterminé que ladite pression de fluide détectée est inférieure à ladite pression de fluide prédéterminée.

**13.** Véhicule à groupe motopropulseur hybride selon la revendication 9, comportant en outre un embrayage de roue libre (4) interposé entre ladite transmission et lesdites roues motrices, afin de désengager lesdites roues motrices dudit premier train de transmission en réponse à un signal indicatif d'une demande de puissance détectée nulle.

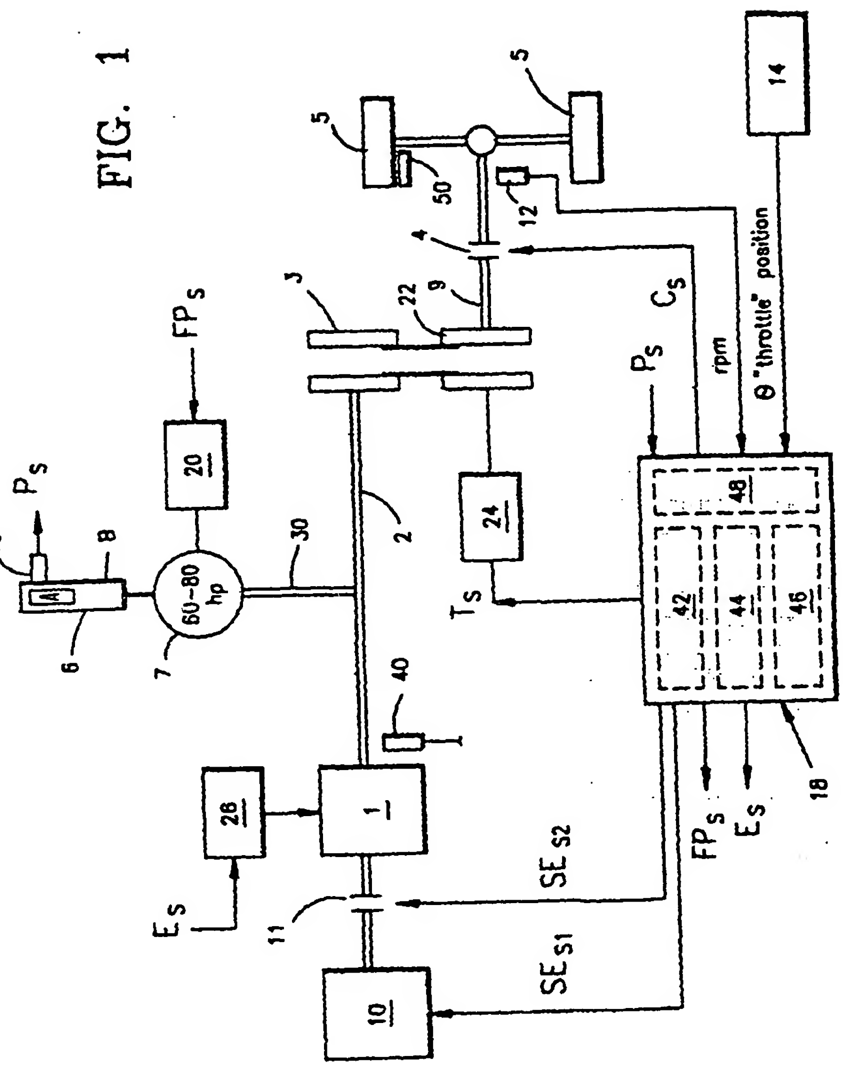
**14.** Véhicule à groupe motopropulseur hybride selon la revendication 9, comportant en outre une mémoire (48) contenant un tableau mémorisé effectuant une corrélation de valeurs pour ladite vitesse optimale du moteur et la puissance de sortie du moteur ; et dans lequel lesdits moyens de détermination de la vitesse du moteur appliquent ladite puissance de sortie du moteur déterminée et ladite vitesse du véhicule détectée audit tableau afin de déterminer la vitesse du moteur de rendement optimum.

**15.** Procédé de commande d'un véhicule équipé du système de propulsion hybride comprenant des roues motrices (5), un moteur principal (1) pour entraîner les roues motrices, des moyens à déplacement de fluide réversibles (7), un accumulateur pour accumuler une pression de fluide (6), une transmission continuellement variable (3) ayant une poulie mobile (22) de diamètre effectif variable et un dispositif de commande pour déplacer mécaniquement cette poulie afin d'en changer le diamètre effectif, ledit procédé comprenant les étapes consistant à :

- détecter la vitesse du véhicule ;
- détecter la pression de fluide régnant dans l'accumulateur ;
- détecter la puissance demandée au véhicule par le conducteur ;
- alimenter en pression de fluide provenant de l'accumulateur le dispositif à déplacement de fluide réversible, afin d'utiliser le dispositif à déplacement de fluide réversible en moteur pour entraîner lesdites roues motrices en réponse à un signal indiquant une puissance demandée supérieure à celle délivrée en sortie du moteur principal ;
- pomper une pression de fluide dans l'accumulateur, en utilisant une partie de la puissance de sortie du moteur principal pour entraîner les moyens à déplacement de fluide réversibles en pompe, en réponse à une pression de fluide détectée inférieure à une valeur prédéterminée ;
- comparer la pression de fluide détectée à une pression de fluide minimale prédéterminée et générer un signal de demande lorsqu'il est déterminé que la pression de fluide détectée est inférieure à la pression de fluide basse prédéterminée ;
- déterminer une puissance de sortie supplémentaire suivant le signal de demande et déterminer une puissance de sortie du moteur en tant que somme algébrique de la demande de puissance détectée et de la puissance de sortie supplémentaire ;
- commander la vitesse de rotation du moteur principal en changeant le diamètre effectif de la poulie mobile en réponse à un signal de transmission ; et

- déterminer une vitesse du moteur de rendement optimum suivant la puissance de sortie du moteur déterminée et la vitesse du véhicule détectée et délivrer en sortie le signal de transmission suivant la vitesse du moteur déterminée.

16. Procédé selon la revendication 15 dans lequel ledit système de propulsion comprend une mémoire (48) contenant un premier tableau mémorisé effectuant une corrélation de valeurs de vitesse optimale du moteur et de puissance de sortie du moteur déterminée, et un deuxième tableau effectuant une corrélation de valeurs de vitesse du véhicule et desdits signaux de transmission, chacune desdites vitesses de transmission représentant un rapport de transmission pour atteindre une vitesse optimale du moteur ; et dans lequel ladite détermination de la vitesse optimale du moteur s'effectue en appliquant la puissance de sortie du moteur déterminée et la vitesse du véhicule détectée auxdits tableaux, afin de sélectionner une vitesse du moteur de rendement optimum pour ladite puissance de sortie du moteur déterminée et ladite vitesse du véhicule détectée et pour établir ledit signal de transmission.


60-80 hp
$P_S$
$FP_S$
$T_S$
$C_S$
rpm
θ "throttle" position
$E_S$
$SE_{S1}$
$SE_{S2}$
A
1
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3
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FIG. 1

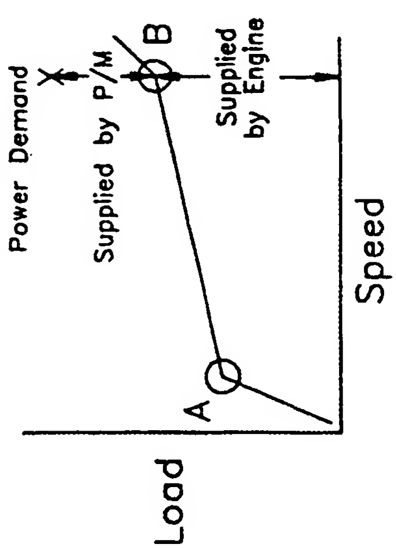



FIG.2A

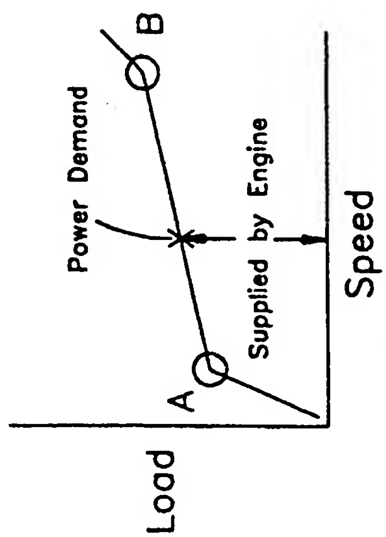



FIG. 2B

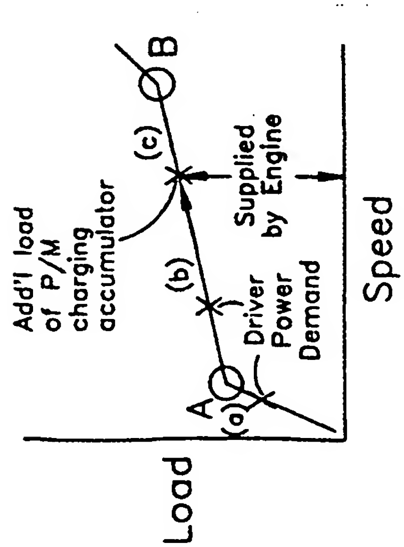



FIG. 2C

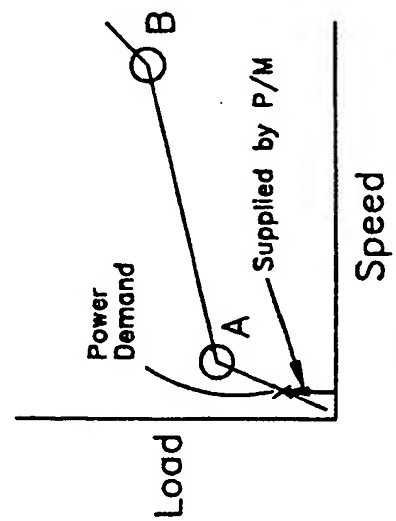



FIG. 2D

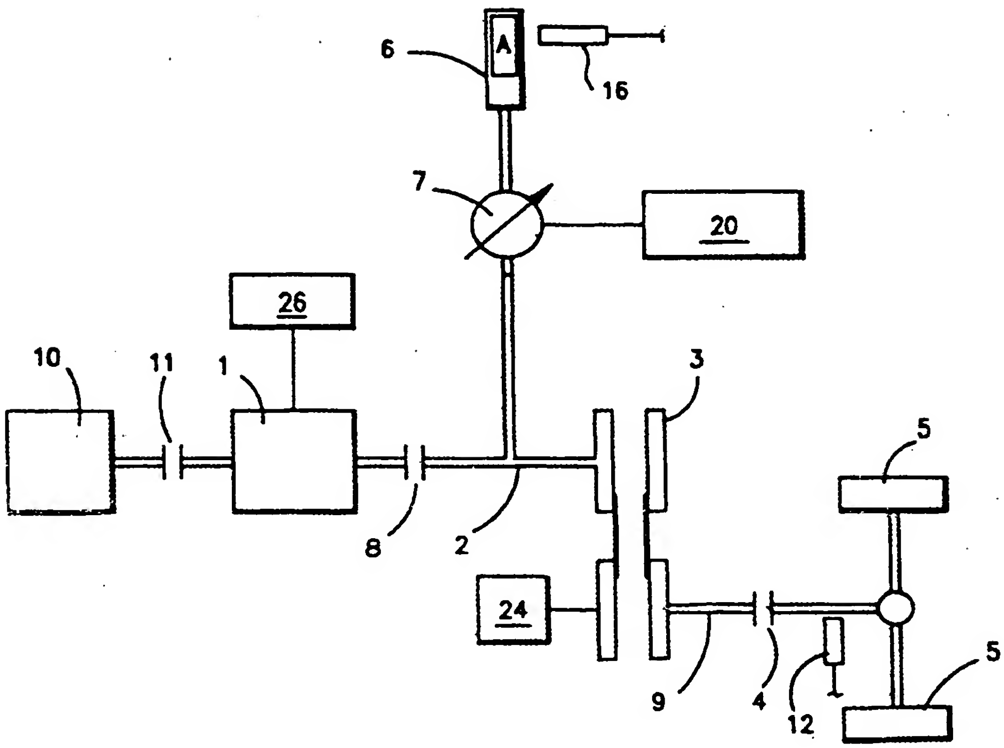
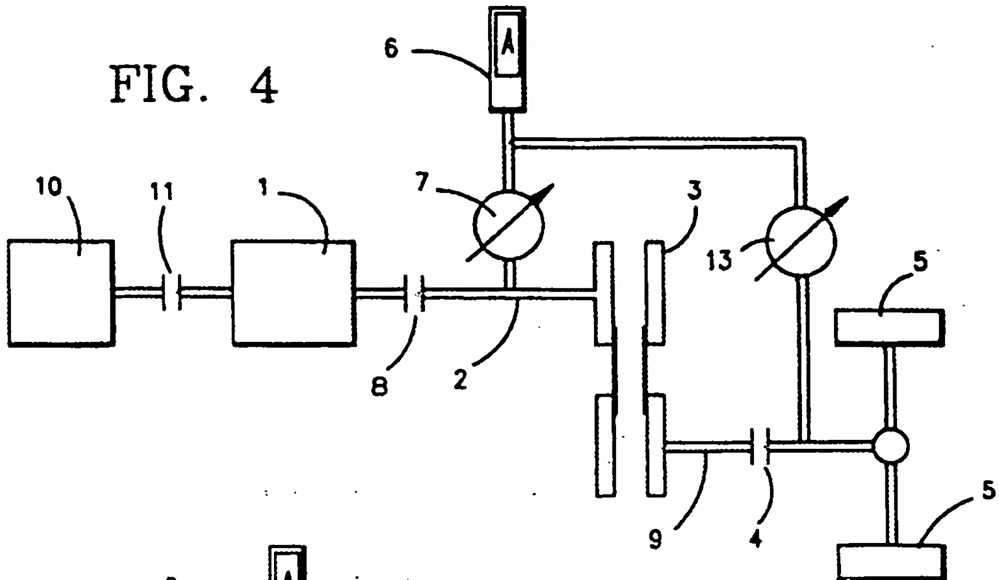



FIG. 3

FIG. 4



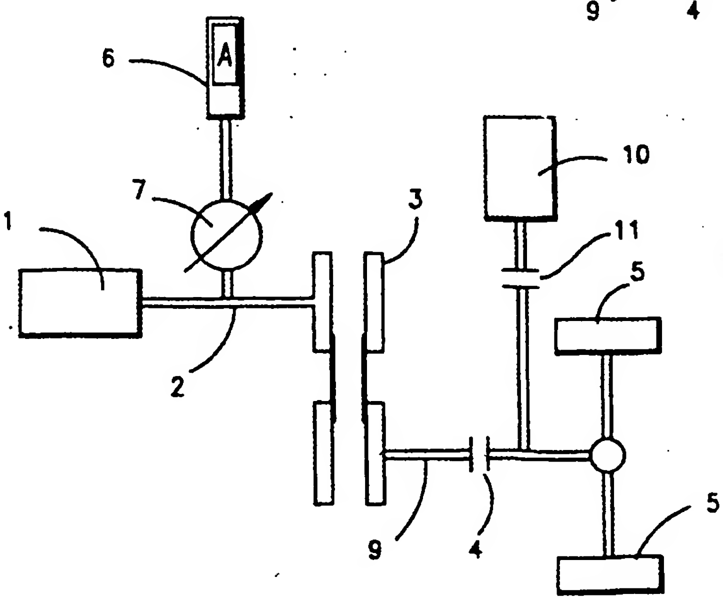
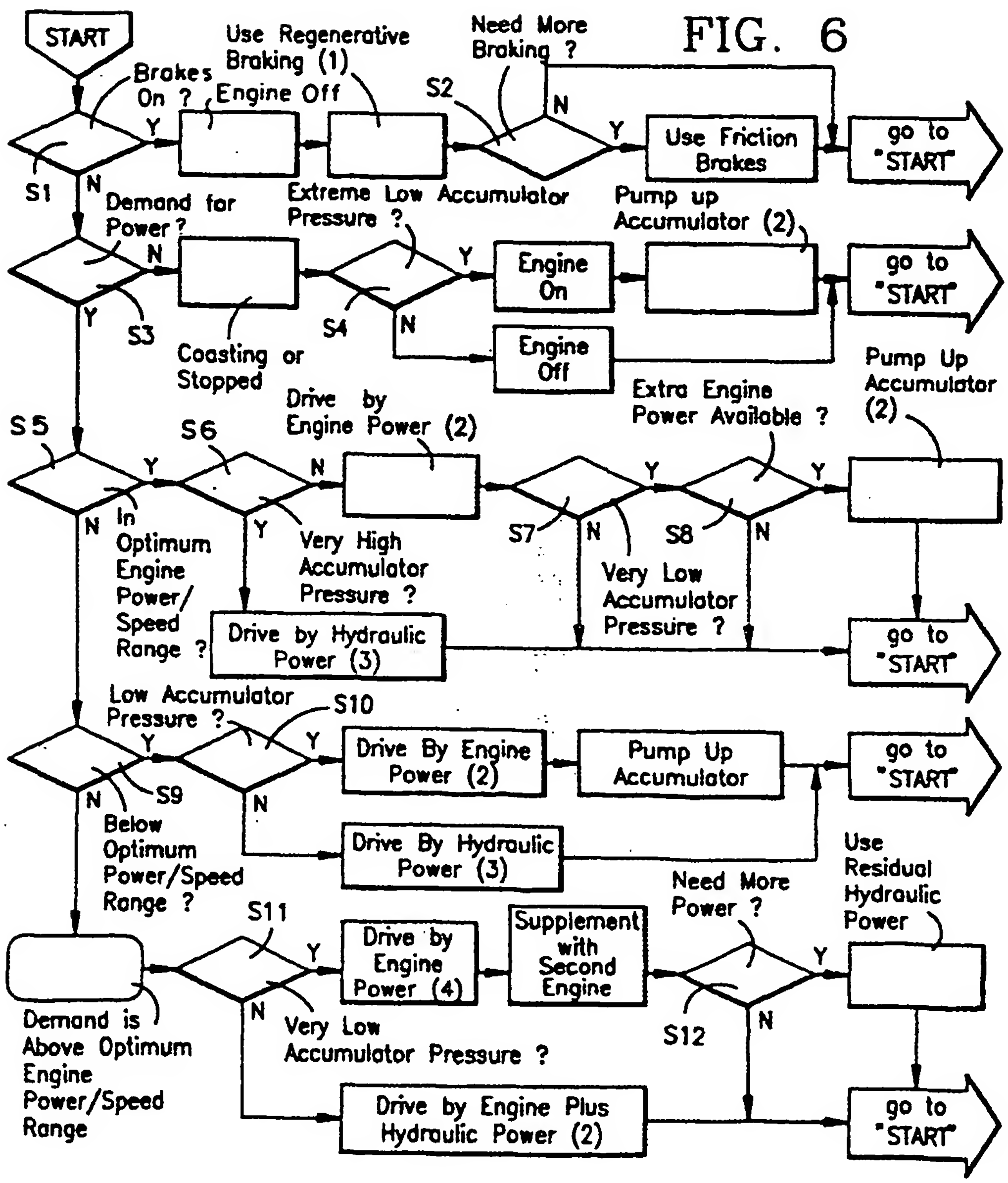




FIG. 5

FIG. 6


START
Brakes On ?
Use Regenerative Braking (1)
Engine Off
Need More Braking ?
S2
Use Friction Brakes
go to "START"
S1
Demand for Power ?
Extreme Low Accumulator Pressure ?
Pump up Accumulator (2)
Engine On
Engine Off
S3
S4
Coasting or Stopped
Drive by Engine Power (2)
Extra Engine Power Available ?
Pump Up Accumulator (2)
S5
S6
In Optimum Engine Power/ Speed Range ?
Very High Accumulator Pressure ?
S7
S8
Very Low Accumulator Pressure ?
Drive by Hydraulic Power (3)
Low Accumulator Pressure ?
S10
Drive By Engine Power (2)
Pump Up Accumulator
S9
Below Optimum Power/Speed Range ?
Drive By Hydraulic Power (3)
Use Residual Hydraulic Power
Need More Power ?
S11
Drive by Engine Power (4)
Supplement with Second Engine
Demand is Above Optimum Engine Power/Speed Range
Very Low Accumulator Pressure ?
S12
Drive by Engine Plus Hydraulic Power (2)
Y
N